PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 15670-029WO1	**FOR FURTHER ACTION**	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below
International application No. PCT/US04/17237	International filing date *(day/month/year)* 01 June 2004 (01.06.2004)	(Earliest) Priority Date *(day/month/year)* 30 May 2003 (30.05.2003)

Applicant THE REGENTS OF THE UNIVERSITY OF CALIFORNIA

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of __4__ sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the Report**
   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (See Box II).

4. With regard to the **title**,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

   ☐ the text is approved as submitted by the applicant.

   ☒ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   ☒ as suggested by the applicant.   ☐ None of the figures

   ☐ because the applicant failed to suggest a figure.

   ☐ because this figure better characterizes the invention.

INTERNATIONAL SEARCH REPORT

Box III TEXT OF THE ABSTRACT (Continuation of Item 5 of the first sheet)

A technique is provided for applying an algebraic multigrid method to analysis of circuit networks with regular and irregular circuit patterns (Figure 1). Smothing is performed at each level in the restriction proess from the finest level (110) to the coarsest level (130) and in the interpolation process from the coarsest level (130) to the finest level (110). Adaptive processing may be applied to the grid coarsening and error smoothing operations to increase processing speed.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/17237

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : G06F 17/50
US CL . 716/5
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 716/5

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
IEEE, EAST search terms: multigrid, multi, grid, power, coarse, fine, granular, circuit

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Kozhaya, J.N et al. Multigrid-like technique for power grid analysis Computer Aided Design, 2001. ICCAD 2001. IEEE/ACM International Conference on , 4-8 Nov. 2001 Pages 480 - 487	1-11, 14-26
X	Kozhaya, J.N. et al. A multigrid-like technique for power grid analysis Computer-Aided Design of Integrated Circuits and Systems, IEEE Transactions on , Volume: 21 , Issue: 10 , Oct. 2002 Pages:1148 - 1160	1-11, 14-26
A	Nassif, S.R. et al. Multi-grid methods for power grid simulation Circuits and Systems, 2000. Proceedings. ISCAS 2000 Geneva. The 2000 IEEE International Symposium on , Volume: 5 , 28-31 May 2000 Pages:457 - 460 vol.5	1-26

☒ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance		
"E"	earlier application or patent published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 October 2004 (20.10.2004)	17 DEC 2004

Name and mailing address of the ISA/US	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703) 305-3230	Matthew Smith James R. Matthew Telephone No. (703)308-1782

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	La Scala, M. et al. A relaxation type multigrid parallel algorithm for power system transient stability analysis Circuits and Systems, 1989., IEEE International Symposium on , 8-11 May 1989 Pages:1954 - 1957 vol.3	1-26
A	La Scala, M. et al. Relaxation/Newton methods for concurrent time step solution of differential-algebraic equations in power system dynamic simulations Circuits and Systems I: Fundamental Theory and Applications, IEEE Transactions on [see also Circuits and Systems I: Regular Papers, IEEE Transactions on] , Volume: 40 , Issue: 5 , May 1993 Pages:317 - 330	1-26
X	Kai Wang et al. Power/ground mesh area optimization using multigrid-based technique [IC design] Design, Automation and Test in Europe Conference and Exhibition, 2003 , 2003 Pages:850 - 855	1-11, 14-26
X, P	Zhengyong Zhu et al. Power network analysis using an adaptive algebraic multigrid approach Design Automation Conference, 2003. Proceedings , 2-6 June 2003 Pages:105 - 108	1-26

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: BING AI FISH & RICHARDSON P.C. 12390 EL CAMINO REAL SAN DEIGO, CA 92130	**PCT** WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY (PCT Rule 43*bis*.1)

	Date of mailing (*day/month/year*)	**17 DEC 2004**

Applicant's or agent's file reference 15670-029WO1	**FOR FURTHER ACTION** See paragraph 2 below

International application No. PCT/US04/17237	International filing date (*day/month/year*) 01 June 2004 (01.06.2004)	Priority date (*day/month/year*) 30 May 2003 (30.05.2003)

International Patent Classification (IPC) or both national classification and IPC

IPC(7): G06F 17/50 and US Cl.: 716/5

Applicant

THE REGENTS OF THE UNIVERSITY OF CALIFORNIA

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1. This opinion contains indications relating to the following items:

☒ Box No. I Basis of the opinion

☐ Box No. II Priority

☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

☐ Box No. IV Lack of unity of invention

☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

☐ Box No. VI Certain documents cited

☒ Box No. VII Certain defects in the international application

☐ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/ US
 	
    Mail Stop PCT, Attn: ISA/US
    Commissioner for Patents
    P.O. Box 1450
    Alexandria, Virginia 22313-1450
Facsimile No. (703) 305-3230
	Authorized officer
	
	Matthew Smith
	
	Telephone No.: (703)308-1782

Form PCT/ISA/237 (cover sheet) (January 2004)

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This opinion has been established on the basis of a translation from the original language into the following language _____, which is the language of a translation furnished for the purposes of international search (under Rules 12.3 and 23.1(b)).

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material

      ☐ a sequence listing

      ☐ table(s) related to the sequence listing

   b. format of material

      ☐ in written format

      ☐ in computer readable form

   c. time of filing/furnishing

      ☐ contained in international application as filed.

      ☐ filed together with the international application in computer readable form.

      ☐ furnished subsequently to this Authority for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. V Reasoned statement under Rule 43 *bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	12-13	YES
	Claims	1-11, 14-26	NO
Inventive step (IS)	Claims	12-13	YES
	Claims	1-11, 14,-26	NO
Industrial applicability (IA)	Claims	1-26	YES
	Claims	NONE	NO

2. Citations and explanations:

Please See Continuation Sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

Claims 23 are objected to under PCT Rule 66.2(a)(iii) as containing the following defect(s) in the form or contents thereof: There is 2 claim 23s and no claims 24. One of the claims 23 needs to be renumbered to be claim 24.

Supplemental Box
In case the space in any of the preceding boxes is not sufficient.

V. 2. Citations and Explanations:

Claims 1-26 lack novelty under PCT Article 33(2) as being anticipated by Kozhaya et al, "A multigrid-like technique for power grid analysis", Computer-Aided Design of Integrated Circuits and Systems, IEEE Transactions on, Volume: 21 , Issue: 10, Oct. 2002, Pages:1148 - 1160.

In reference to claim 1, Kozhaya teaches a method comprising: representing a circuit network by using a matrix of nodes having fine nodes and coarse nodes; applying an adaptive coarse grid construction procedure to assign grid nodes in the matrix as either coarse grid nodes or fine grid nodes according to (1) circuit activities and (2) to a matrix structure of the matrix to construct a plurality of levels of grids with different numbers of nodes to respectively represent the circuit network; and applying iterative smoothing operations at selected local fine grids corresponding to active regions at a finest level obtained in the adaptive coarse grid construction procedure. (page 1153, column 2 - page 1156, column 2)

In reference to claim 2, Kozhaya teaches wherein the coarse grid nodes are divided into non-adaptive coarse nodes which are selected according to the matrix structure, and adaptive coarse nodes which are selected according to circuit activities. (page 1154, column 2 - page 1155, column 2)

In reference to claim 3, Kozhaya teaches wherein, in assigning non adaptive coarse nodes, a node with a maximum potential in its degree is selected as a first non-adaptive coarse node and each neighboring node of the first non-adaptive coarse node is temporality assigned as a fine node, and wherein a potential of each neighboring node of the first non-adaptive coarse node is increased by one unit before a next level of assigning coarse and fine grid nodes so that each fine node has at least one neighboring coarse node upon completion of assigning non adaptive coarse nodes. (page 1154, column 2 - page 1155, column 2)

In reference to claim 4, Kozhaya teaches wherein an adaptive coarse node is selected according to a first-order derivative of a nodal voltage. (page 1154, column 2 - page 1155, column 2)

In reference to claim 5, Kozhaya teaches wherein a coarse node is selected as an adaptive coarse node when the first order derivative the coarse node is greater than a threshold value. (page 1154, column 2 - page 1155, column 2)

In reference to claim 6, Kozhaya teaches selecting adaptive coarse nodes in a level that is not the finest level. (page 1154, column 2 - page 1155, column 2)

In reference to claim 7, Kozhaya teaches applying a restriction mapping of nodes in the level to a next level with less nodes; performing iterative smoothing operations again at the next level; and repeating the restriction mapping and the iterative smoothing operations until reaching a level of nodes which are solvable by a direct matrix solving method. (page 1152, column 2 - page 1153, column 2)

Supplemental Box
In case the space in any of the preceding boxes is not sufficient.

In reference to claim 8, Kozhaya teaches applying an interpolation mapping of nodes in the level to a next level with more nodes; performing iterative smoothing operations again at the next level; and repeating the interpolation mapping and the iterative smoothing operations until reaching the finest level of nodes. (page 1155, column 2 - page 1156, column 2)

In reference to claim 9, Kozhaya teaches computing a residual value of an error after the iterative smoothing operations at the finest level; comparing the residual value to a pre-determined threshold; terminating any further processing when the residual value is less than the threshold; and when residual value is greater than the threshold, the method further comprising: applying a restriction mapping of nodes in the finest level to a next coarser level with less nodes, performing iterative smoothing operations again at the next coarser level; and repeating the restriction mapping and the iterative smoothing operations until reaching a coarsest level of nodes which is solvable by a direct matrix solving, applying an interpolation mapping of nodes in the coarsest level to a next finer level with more nodes, performing iterative smoothing operations at the next finer level, repeating the interpolation mapping and the iterative smoothing operations until reaching the finest level of nodes, and repeating the restriction mapping, the interpolation mapping and the respective iterative smoothing operation at different levels until the residual value at the finest level is less than the threshold. (page 1152, column 2 - page 1155, column 2)

In reference to claim 10, Kozhaya teaches dynamically changing designations of active and inactive regions of the circuit network according to circuit activities at different times. (page 1154, column 2 - page 1155, column 2)

In reference to claim 11, Kozhaya teaches applying iterative smoothing operations in active regions more frequently in time than in inactive regions. (page 1154, column 2 - page 1155, column 2)

In reference to claim 14, Kozhaya teaches a method comprising: representing a circuit network by using a plurality of levels of grids with different numbers of nodes to represent the circuit network according to an algebraic multigrid method; applying a restriction mapping from one level to a next coarser level to propagate computation results of the one level to the next coarse level; applying an interpolation mapping from one level to a next finer level to propagate computation results of the one level to the next finer level; performing an iterative smoothing operation at each level to obtain computation results of each level comprising states of nodes in each level; and repeating (1) the restriction mapping and the iterative smoothing operation from the finest level to the coarsest level and (2) the interpolation mapping and the iterative smoothing operation from coarsest level back to the finest level for at least one time to obtain a solution to the circuit network. (page 1153, column 2 - page 1156, column 2)

In reference to claim 15, Kozhaya teaches wherein the coarsest level is a level where a matrix equation for nodes in the level is solvable by a direct matrix method (page 1152, column 2 - page 1153, column 2)

In reference to claim 16, Kozhaya teaches wherein at least one level includes nodes corresponding to only selected circuit regions in the circuit network that are active and does not include nodes corresponding to inactive circuit regions in the circuit network. (page 1154, column 2 - page 1155, column 2)

In reference to claim 17, Kozhaya teaches assigning regions in the finest level with nodes corresponding to active circuit regions in the circuit network
as active local fine grids; and performing the iterative smoothing operation only in the active local fine grids in the finest level to obtain computation results of the finest level. (page 1154, column 2 - page 1155, column 2)

In reference to claim 18, Kozhaya teaches assigning regions in a level with nodes corresponding to active circuit regions in the circuit network as active local grids and other regions in that level as in inactive grids; and performing the interactive smoothing operation in an active local grid more frequently than in an inactive grid. (page 1154, column 2 - page 1155, column 2)

In reference to claim 19, Kozhaya teaches applying an adaptive coarse grid construction procedure to assign grid nodes in the matrix as either coarse grid nodes or fine grid nodes. (page 1154, column 2 - page 1155, column 2)

In reference to claim 20, Kozhaya teaches wherein a coarse node is assigned by: assigning a node with a maximum potential to its degree as a first coarse node and all neighboring nodes as initial fine nodes; for each of the initial fine nodes, increasing a potential of each of neighboring nodes by one unit; assigning a node which has a maximum potential among other nodes except for the first coarse node as a second coarse node; and repeating the assigning for nodes that are not assigned as coarse nodes until all nodes are assigned. (page 1154, column 2 - page 1155, column 2)

In reference to claim 21, Kozhaya teaches wherein the coarse nodes are selected according to their values of a first order derivative of a nodal voltage. (page 1154, column 2 - page 1155, column 2)

In reference to claim 22, Kozhaya teaches a method comprising: applying an algebraic multigrid method to a matrix representative of a circuit network to construct a plurality of matrices with different degrees of coarsening grids; representing regions in the circuit network exhibiting to active circuit activities with active grids and regions in the circuit network exhibiting less active circuit activities

Supplemental Box
In case the space in any of the preceding boxes is not sufficient.

with inactive grids; and performing an iterative smoothing operation in an active grid more frequently than in an inactive grid to reduce an amount of computation. (page 1153, column 2 - page 1156, column 2)

In reference to the first claim 23, Kozhaya teaches applying a restriction mapping of nodes in a coarse grid to a next coarser grid; performing the iterative smoothing operation at the next coarser grid; and repeating the restriction mapping and the iterative smoothing operation until reaching the coarsest grid which has a matrix equation that is solvable by a direct matrix solving method (page 1152, column 2 - page 1153, column 2)

In reference to the second claim 23, Kozhaya teaches applying an interpolation mapping of nodes in one grid to a next finer grid; performing the iterative smoothing operation at the next finer level; and repeating the interpolation mapping and the iterative smoothing operation until reaching the finest grid. (page 1154, column 2 - page 1155, column 2)

In reference to claims 25 and 26 drawn to articles comprising a machine-readable medium that stores machine-executable instructions causing a machine to perform the methods rejected in claims 1-23 above, the same rejection applies.

Claims 12 and 13 meet the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest applying different models to passive circuits exhibiting resistance and capacitance without inductance and passive circuits exhibiting inductance wherein a circuit network is represented by using a matrix of nodes having fine nodes and coarse nodes; an adaptive coarse grid construction procedure is applied to assign grid nodes in the matrix as either coarse grid nodes or fine grid nodes according to (1) circuit activities and (2) to a matrix structure of the matrix to construct a plurality of levels of grids with different numbers of nodes to respectively represent the circuit network; and iterative smoothing operations at selected local fine grids are applied corresponding to active regions at a finest level obtained in the adaptive coarse grid construction procedure.

NOTES TO FORM PCT/ISA/220 (continued)

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

> (i) the claim is unchanged;
>
> (ii) the claim is cancelled;
>
> (iii) the claim is new;
>
> (iv) the claim replaces one or more claims as filed;
>
> (v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
   "Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."

2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
   "Claims 1 to 15 replaced by amended claims 1 to 11."

3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
   "Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
   "Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."

4. [Where various kinds of amendments are made]:
   "Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under Article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international application is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments and any accompanying statement, under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the time of filing the amendments (and any statement) with the International Bureau, also file with the International Preliminary Examining Authority a copy of such amendments (and of any statement) and, where required, a translation of such amendments for the procedure before that Authority (see Rules 55.3(a) and 62.2, first sentence). For further information, see the Notes to the demand form (PCT/IPEA/401).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see the *PCT Applicant's Guide*, Volume II.